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ABSTRACT

As part of continuing research aimed at identifying optimal methods for training Navy personnel who have achieved marginal scores on military selection tests, flash card instruction methods were adapted for application to a comprehensive range of basic mathematical operations involved in a previously developed course in fundamental mathematics. Supplementing the standard course work with flash card instruction did not result in significantly higher performance gains, and the study concluded that applying flash methods to the relatively wide range of content complexity involved in this study was not effective. (Author/BH)

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RESEARCH MEMORANDUM SRM 70-20 JUNE 1970

THE EFFECTIVENESS OF FLASH CARDS IN A MATHEMATICS SELF-STUDY COURSE FOR GROUP IV PERSONNEL

Ray E. Main

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THE EFFECTIVENESS OF FLASH CARDS IN A MATHEMATICS SELF-STUDY COURSE FOR GROUP IV PERSONNEL

by

Ray E. Main

June 1970

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Research Memorandum SRM 70-20

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SUMMARY AND CONCLUSIONS

Problem

The Naval Personnel and Training Research Laboratory (NPTRL) is currently investigating methods for training Navy enlisted men who are classified as Mental Group IV on the basis of AFQT scores. One specific research effort involves the identification of training procedures for effectively augmenting a self-study course in basic mathematical operations.

Background and Requirements

An experimental program has been established at NPTRL to provide controlled conditions for training Mental Group IV personnel (those with scores on the Armed Forces Qualifications Test which fall between the 10th and 30th percentiles). Experimental classes have been conducted in a variety of subject matter including basic mathematics. In an earlier study, an attempt was made to assess the effectiveness of supplementing the instructional material of the mathematics course with flash card drill. The mathematical content was presented both with and without flash card supplementation so that performance gains made under each condition could be compared. Unfortunately, consistently significant test gains were not achieved under either condition so a meaningful comparison of test gains could not be performed. All previous and subsequent classes achieved significant levels of improvement using the basic course materials. It was decided, therefore, to repeat the experiment with a new (and hopefully more typical) group of trainees.

Approach

Sixteen Group IV personnel were given training in basic arithmetic operations. Part of the training was supplemented by practice with flash card materials and the effects of this additional instruction were determined.

Findings and Conclusions

In general, students demonstrated significant test gains on all performance indices. The additional practice with flash cards did not, however, increase test gains by a significant amount despite the fact that results indicated a potential for further improvement. It is pointed out that in this study flash card instruction was applied to problems covering a broad range of complexity. Flash card instruction is typically applied to very basic types of mathematical operations and the results of this experiment should not be interpreted as questioning the usefulness of flash cards as typically employed.

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THE EFFECTIVENESS OF FLASH CARDS IN A MATHEMATICS SELF-STUDY COURSE FOR GROUP IV PERSONNEL

A. Introduction

The Naval Personnel and Training Research Laboratory (NPTRL) is conducting a research program to develop and evaluate methods for training Navy personnel who achieve marginal scores on military selection tests. One of the content areas under investigation is basic arithmetic skills. An experimental mathematics course based on self-study methods has been developed and found effective for training Mental Group IV students (personnel whose scores on the Armed Forces Qualification Test fall between the 10th and 30th percentiles). Following the development of this set of course materials, training modifications were introduced and their effects experimentally evaluated.

Instructors had reported that Group IV trainees appear to experience difficulty in remembering, from day to day, procedures which they had supposedly mastered. It was hypothesized, in accordance with behavioral theories on the development of habit strength, that appropriate repetition of relevant problem-solving responses would promote retention, and thereby raise performance levels.

Some care had to be given in planning how repetition was to be introduced. Simply repeating the same operations over and over might bore students and reduce motivation. Flash card instruction was selected as an appropriate training supplement since it provided repetition of training in a manner that was both different from and compatible with the basic self-study course.

A preliminary investigation was undertaken to compare test gains achieved with and without flash card supplementation.[1] The results of this investigation were inconclusive; gains could not be compared because a significant level of improvement was not achieved under either condition. Since all previous and subsequent classes had achieved significant levels of improvement using the basic course materials, the performance of the class under investigation was judged to be atypical. Present research goals were to repeat the flash card experiment with a different group of trainees in order to determine whether or not a class that does make effective use of the basic course materials will benefit from additional practice with flash cards.

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[1] Main, R. E., Development and evaluation of an experimental course in applied mathematics for Group IV personnel. San Diego: U. S. Naval Personnel and Training Research Laboratory, September 1969. (Research Report SRR 70-8)

B. Method

1. Subjects

Subjects consisted of a class of 16 Group IV personnel who had just completed Navy recruit training. Aptitude scores taken from trainees' records are presented in Appendix A.

2. Materials

The basic instructional materials used for this study were developed by NPTRL specifically for training Navy Group IV personnel. The course work was similar to programmed instruction in that students worked individually at their own rate and were periodically required to make responses. Unlike typical programmed instruction, the content was not organized into frames, and feedback was provided only after an entire lesson was completed rather than after each separate response.

The card decks used in this experiment were somewhat unique in that they were designed to cover operations of a complexity which would not typically be associated with flash card instruction. On some cards, only a portion of a problem was covered. While students cannot be expected to work in their heads problems such as multiplying two 3-digit numbers, they can be expected to distinguish whether or not certain critical operations have been performed correctly. For example, they should be able to look at a multiplication problem which had been worked, and indicate whether or not rows have been properly indented.

The card decks were designed for individual drill. Each problem was printed on the front of a white three-by-five card, with the answer on the back. Each specific type of problem appeared twice (with different numerical values) in order to promote repetition but, at the same time, discourage students from simply memorizing answers. (Examples of the 116 mathematics problems which were used on flash cards are displayed in Appendix B.)

The complete deck of cards was divided into two sets. Set A consisted of 62 cards covering multiplication of whole numbers, operations with fractions, and computation of percentage problems. Set B consisted of 54 cards covering division of whole numbers, operations with decimals, and measurement operations (involving computations and conversions with linear, square, and cubic units).

The USAFI III Arithmetic Computation Test and the Arithmetic Operations Quiz (AOQ) were the two tests utilized to evaluate performance. The USAFI III is a test commonly used by the military services to establish ability levels for marginal personnel. The AOQ was constructed specifically for the purpose of determining performance levels of Group IV personnel on different aspects of the same basic arithmetic operations covered by the USAFI III. Some of the operations which were covered by test items were not covered by flash card instruction. In comparing performance gains made with and without flash card supplementation, only those test items which were covered by flash card

problems were considered. Twenty-six test problems (Problem Set A) were covered by Card Set A and 24 test problems (Problem Set B) were covered by Card Set. B.

3. Procedure

Trainees worked with the basic self-study mathematics course for approximately one hour a day over a period of 14 days. The same sequence of lessons was given to all trainees but each worked at his own pace. Experimental treatments were administered so that all trainees worked with flash cards for about 10 minutes a day, but each trainee worked with only one set. Half of the trainees worked with cards from Set A and half worked with cards from Set B. Trainees were instructed to go through the cards quickly and to decide on their response to each before checking the answer. They were encouraged to record the number of flash card problems they had answered each day and the number of errors they made. If a trainee made very few errors, it was suggested that he try to go through the cards more quickly.

From past experience, it was correctly predicted that many trainees would not be able to cover all portions of the course. It was felt that slower students would profit more from working only with those cards which covered the more basic operations. Rather than give students an entire card set to work with from the start, each set of cards was divided into two subsets of progressively difficult operations. Initially each student was given only the first subset of cards to work with. As soon as he started to work a lesson which was relevant to the advanced flash card instruction, the second subset was added to his deck.

C. Results

A previous attempt to evaluate the effectiveness of flash card instruction was confounded by the inability of trainees to profit from the basic course materials. Therefore, in the present study, it is appropriate to examine overall test gains. Mean improvement scores were computed separately for each of the two achievement tests, the USAFI III and the AOQ. Each trainee's improvement score was computed by subtracting the number of posttest errors from the number of pretest errors. Mean improvement scores on both tests were found to be statistically significant (for the USAFI III, mean = 4.06, SD = 5.31, $p<.01$; for the AOQ, mean = 8.44, SD = 5.62, $p<.001$). It is clear that trainees did make effective use of the basic instructional materials.

Having determined that overall performance gains were significant, one can ask what gains in performance can be attributed to the use of flash cards? To determine the effects of flash card instruction two improvement scores were computed for each trainee. One score represented performance on test problems that (for that trainee) were covered by flash cards. The other score represented performance on problems not covered by flash cards. Each score was computed by summing gains (differences between pretest and posttest raw scores)

made over relevant items on the USAFI III and AOQ tests. Relevant items were limited to those test problems which were covered by flash card Sets A and B.

In Table 1 a summary of test data is presented, and mean performance gains for treatments and problem sets are indicated.

TABLE 1

Mean Performance Gains for Treatments and Problem Sets

Problem Set	Subjects	Treatments		Averaging Groups and Treatments
		Without Flash Cards	With Flash Cards	
A	Group 1	4.6	---	5.3
	Group 2	---	6.0	
B	Group 1	---	2.8	2.3
	Group 2	1.9	---	
Averaging Groups and Sets		3.3	4.4	

An analysis of variance employing a cross-over design was used to test for main effects.[2] A summary of this analysis is presented in Table 2.

From Tables 1 and 2 we may conclude that the addition of flash card instruction did not increase test gains by a significant amount and that trainees made greater gains over Problem Set A than Problem Set B.

It might be questioned whether the gains made, using basic course materials, left room for flash card drill to cause improvement. Mean pretest and posttest error scores for those 50 problems covered by flash card instruction were, therefore, computed and compared. Before training, the mean number of errors made was 23.4. Following training, the mean number of errors made was 15.9. Although considerable improvement was made, the failure of flash card instruction to augment basic course materials can hardly be attributed to ceiling effects.

D. Discussion

The present research goal was to determine whether or not a class that does make effective use of basic course materials will benefit

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[2]Edwards, A. L., Experimental design in psychological research. New York: Holt, Rinehart and Winston, 1960

TABLE 2

Analysis of Variance for Effects
of Treatments, Problem Sets, and Subjects

Source of Variation	Sum of Squares	df	Mean Square	F	Level of Significance
Treatments (With and without flash cards)	10.2	1	10.2	1.1	>.05
Problem Sets (A and B)	72.0	1	72.0	7.7	<.05
Subjects	237.9	15	15.9	1.7	>.05
Error	130.8	14	9.3		
Total	450.9	31			

from additional practice with flash cards. In order to realize this goal, certain performance outcomes were required. Trainees had to achieve significant gains using the basic course materials, but still have room for additional improvement. The test performance of the present class was quite satisfactory in these respects.

Supplementing the course with flash card drill did not increase performance gains by a significant amount. It should be noted that flash card instruction is typically employed for very basic types of mathematical problems such as learning multiplication tables. The experiment reported upon here was not designed to investigate that type of flash card usage. Therefore, results of this study should not be interpreted as raising questions about the usefulness of flash cards as typically employed in education and training. Indications are that flash cards may lose effectivenss when applied to complex material. Further investigations should be directed toward clarifying how flash card effectiveness varies with problem complexity for mathematical operations.

Appendix A

Pretraining Aptitude Test Scores*

Trainee Identification Number	Navy Basic Test Battery Indices: General Classification Test (GCT)	Navy Basic Test Battery Indices: Arithmetic Test (ARI)	Armed Forces Qualifications Test (AFQT)
1	40	38	19
2	39	38	18
3	33	34	16
4	44	40	21
5	47	42	23
6	30	42	24
7	33	40	19
8	34	36	20
9	35	40	28
10	40	38	28
11	37	38	14
12	33	43	27
13	22	36	15
14	25	30	12
15	39	43	23
16	37	39	15
Mean	37.5	38.6	20.1

*The GCT and ARI are standard scores; the AFQT is a percentile score.

APPENDIX B

Examples of Flash Card Problems

Multiplication

$$\begin{array}{r} 231 \\ \times \quad 3 \\ \hline \end{array}$$

Division

$$5/\overline{7} \quad \frac{1}{} \quad r ____$$

Which is correct?

(a)	(b)	(c)
21	21	21
x 33	x 33	x 33
63	63	54
63	63	
693	126	

Which is correct?

(a)	(b)	(c)
330	303	33
4/ 132	4/ 132	4/ 132
-12	-12	-12
12	1	12
-12	-0	-12
00	12	00
-00	-12	
00	00	

Fractions

$\frac{2}{5} \div \frac{3}{2} = _____$

Decimals

1.5 + .62 = _____

Change the problem so it can be worked more easily.

$1\frac{1}{4} \times 3\frac{2}{3}$

Can be changed to

$\frac{}{4} \times \frac{}{3}$

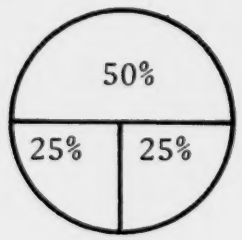
What will our final answer be?

$$4\overline{)\,2.2}\quad 5$$
$$-2\,0$$
$$2$$

APPENDIX B (Continued)

Percentages

Total = $1000



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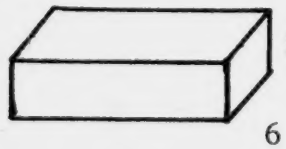

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13. ABSTRACT

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